Why is Modeling and Simulation So Hard to Do?

M&S Commonalities, Interoperable Systems Will Provide Warfighters, Decision Makers Increased Readiness Across Full Spectrum of Conflict

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"No one knows exactly what warfare in the 21st Century will be like. However, one thing is certain – future battlefields will be far different and more complex than 20th Century battlefields. We must be ready...Finding ways to exploit our competitive advantages – quality people and advancing technology – becomes our future readiness challenge."

–Gen. Dennis J. Reimer
Army Chief of Staff

The issue of Simulation Based Acquisition poses an interesting dichotomy for the Defense Department and its support industries. On the one hand, it holds the potential to be the greatest tool to improve the acquisition process; but on the other hand, the number of systems and programs using simulation in new, innovative ways are few and far between. Given the enormous pressure to reduce costs, save time, and make innovative uses of technology in all facets of our lives, why does this obvious area of need seem to be lagging behind? It appears that the difficulties are not technological as much as they are cultural, organizational, and yes, even a function of policy.

The Stated Need

The use of modeling and simulation (M&S) in the military and its supporting industries is increasing. As these needs increase, the demand for non-technical personnel to provide management and leadership also increases. The senior leadership of each Service express these needs in their individual M&S plans.

The Army Model and Simulation Master Plan[1] promotes the adoption of M&S standards, common tools, and processes for use in all applications throughout the Army. In an effort to invest its resources in an effective and efficient fashion, the Department of the Army intends to use M&S technologies to significantly advance the capabilities of a smaller, power-projection Army capable of land force dominance.[2] The Master Plan requires that the Army seek opportunities for commonality within M&S technologies and capitalize upon them, wherever feasible.

The U.S. Air Force (USAF) Modeling and Simulation Master Plan states the Air Force goal for M&S is to develop a capability, using interoperable M&S systems, to provide warfighters and decision makers the tools to ensure readiness across the full spectrum of conflict.[3] Fully capable of supporting analysis and training, which is integrated throughout all echelons of the Air Force, the Air Force M&S architecture links together many

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types of simulations (e.g., aggregate and detailed computer models, pilots in live aircraft and simulators, and hardware components).

The Air Force has always used models and simulations of reality, considering live field exercises as simulated warfare.[4]

The U.S. Marine Corps (USMC) desires to acquire and apply M&S technologies effectively and efficiently to support USMC roles and missions.[5] Recognizing that the use of M&S enhances training, education, analysis, logistics, planning, and the conduct of operations, the USMC also promotes the use of M&S as the very basis for improving future acquisition decisions, systems testing and evaluation, realignment of force structure, and requirements definition.[6]

The Marine Corps Modeling and Simulation Master Plan states that the Marine Corps will maximize warfighting capability by exploiting world class M&S technology in order to take full advantage of the explosion in information and communications technologies, thereby improving Total Force performance. By ensuring that it simulates before it builds, buys, or fights, the Corps will enhance readiness and training while simultaneously reducing costs.[7]

The Department of the Navy (DON) has stated it will use the appropriate level of M&S in order to support all phases and milestone decisions of the system acquisition cycle.[8] The end-state objectives of the Navy's M&S plan includes a full-scale integration of live, virtual, and constructive simulation into training endeavors, and the enabling of mission planning and rehearsal through the use of M&S.[9]

Photo courtesy Lockheed Martin Corporation

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The Solution

The intent of all the Services and, in many cases, the Congress, seems quite clear, and many of us believe that the domain of M&S that could gain the most from this new technology is the acquisition community. For years, senior acquisition leaders throughout the Department of Defense (DoD) discussed a future goal of streamlining the acquisition process. For people outside the military [and oftentimes, inside], the acquisition life cycle is almost unbelievable. For example, the Air Force began work on the F-14 as early as 1961, the M1 Tank in 1969, and the Stealth Fighter in 1978; in fact, an average acquisition life cycle of 15 years for even small systems is not unusual. The need to streamline is great, and the process has many points that would seem to warrant some technological improvements. Let's look at a few.

Concept Formulation/Defining Requirements. We're all familiar with the cartoon that shows the series of events illustrating how the camel evolved via the acquisition process, when a horse was the original concept. Although a trite example, it does typify what we all experienced, as the user first describes the need and then passes it to the developer, who must then convert the idea into the best technical solution. The challenge is for the user to initially communicate the needed system in operational terms, while the developer must design and develop something that meets the needs in terms of a real, efficient, and maintainable item of equipment.

Further, this is often complicated by language problems, personnel turnover, technology changes, priority

changes, and leadership directions. Of course, the real problem is that users really have a difficult task describing what the new requirement is; by nature, they want everything, they want it today, and they want it cheap! Who can blame them when they are representing the needs of the warfighters, who are always faced with new missions and bigger challenges. The problem is that this often ambitious, yet less-than-detailed Operational Requirements Document (ORD) is very difficult for developers to implement. In addition, as modelers develop many of the capabilities, technical solutions often end up as useful but not consistent with the original requirement. This is not always recognized, as the documentation of the original need is not usually available to the developers. A very long trail, indeed....

Documentation. When the acquisition of the training subsystem alone includes a trailer truckload of documents, it becomes easy to understand why the documentation of the acquisition life cycle is so difficult to manage and often lags behind when development work becomes overwhelming. Certainly, modern information technology can alleviate this problem, simply by automating the existing complex "paper" process. Making use of the current techniques of distributed data systems, electronic conferencing, and Web-based document collaboration would provide not only a ready access to the ORD, but also provide an online ability to document decisions and actions throughout the process. The idea that one phase of the process could pass its experience on to the next, including issues that need resolution and key decisions that help accomplish the requirement, would reduce the time and transfer loss that happens at each milestone. The use of consistent state-of-the-art information technology alone would reduce the process by 15-20 percent.

Simulation in Defining Concepts and Development of the ORD. Remember the hardest thing about doing a term paper in high school? Most of us would probably reply that it was determining the topic and theme of the paper. This process is similar to trying to describe the functional capabilities of a new weapons system, which has become especially difficult with the transition from a requirements-based system to a capability-based approach. One promising alternative approach that uses simulation is the development of a notional system using a dynamic computer model, at the component level of the systems. Modelers would begin by first loading the system that currently exists into a computer simulation that can dynamically and graphically display the appearance and performance capability of the components that make up the system. Depending on the complexity of the system, it could end up being a multi-level model, consisting of "system of systems." As most systems are actually only about 25 percent new technology, the combat developer systematically works through each major sub-system, replacing components with either existing components from other military or civilian systems, or defining a new system based on functional capability. Plugging the new items in, of course, must include a reconfiguration of support systems and recalibration of performance parameters.

Once the developer completes the functional virtual prototype, initial operational testing comes next to determine the prototype's performance capabilities. By injecting the Virtual Prototype into a battle scenario, previously baselined with the existing system, modelers can then see if they are achieving the desired outcomes. Data can be collected for those components that are real, and can be approximated for the completely new pieces. Once the concept is tried out, the performance parameters and the documented functionality can be translated into an ORD, and the virtual prototype can be passed on to the developer to ensure proper understanding of the requirements and maintenance of all the information generated up to this point. Of course, key to this process is ensuring that modelers use the new concepts in such a way that performance can be accurately measured and evaluated in terms of system and sub-system performance, as well as operational and tactical ability. This takes us to our next streamlining opportunity.

Test and Evaluation. Easily the most underutilized element of the overall acquisition community, test and evaluation could provide 25- to 40-percent savings if properly employed throughout the life cycle process. In the first place, most programs wait until the end to begin involving the test and evaluation (T&E) community when, in fact, the T&E experts should be on board from the very beginning. First, at the onset of the concept formulation process, the T&E experts – who understand data collection, performance assessment, and measures of effectiveness – can assist in the formulation process by pointing out those processes already tried, and those that cannot be accurately measured, as described. As the concept is converted into a prototype (hopefully, a virtual prototype as described previously), the T&E experts can help set up ways to measure the effectiveness of the prototype, as well as set up and measure the test program against the current baseline system. In some instances, they can provide facilities or, at the very least, insight, into how to conduct virtual tests, and can even do sophisticated hardware-in-the-loop, engineering-level developmental testing. At the same time, they can develop the test process so that data collected can be used for two other key elements related to Operational Testing – Verification, Validation, and Accreditation; and cost effectiveness. They should also be able to assist in leveraging data from previous developmental tests on notional components from other test activities, further reducing the need for testing. When this is coupled with information technology automation techniques, and information on test experience begins flowing between agencies using and reusing compo-

nent-level data and evaluation tools, the process becomes more efficient, and the life cycle becomes shorter.

A lack of valid data to use in the models, and the lack of facility most of us continue to have in truly working with data-intense decisions, constitute two of the most basic reasons simulation is not easier to implement. Pound for pound, the T&E community has lived in this world much longer than the rest of us, and we could benefit greatly from their experience.

Other Issues. Certainly, I could go on and talk about other areas that could benefit from M&S technology interventions. These could include the use of simulations for setting up virtual production lines; determining parts needs and stock levels; using simulation to simultaneously develop the necessary training systems; using the same notional approach described previously, with its resultant data trail to forecast RAM and logistics support and using a mix of the predecessor data and information available for the components connected together. This discussion could go on for quite some time. However, the examples I just cited should be enough to make the point that the use of simulation in acquisition is not a mysterious process, but rather the managed systematic integration of a new set of technology tools, in an innovative fashion. But, a few stumbling blocks, which are not technical but rather cultural and organizational, may impede the way.

The Problem

Presently, no focused, organizational method exists that ensures individuals are versed in the issues and methods surrounding M&S applications except by on-the-job training. Even within academia, only a few graduate degree programs in Simulation Systems are offered.[10,11] Despite this apparent lack of formal training and education, the need for DoD's expanded use of M&S continues to be viewed as a major solution, for the acquisition world and its activities continue to grow at a significant rate. Without a formal strategy for developing M&S professionals, neither consistent application nor functional standardization within the M&S community can be achieved, and acquisition will continue to go on as usual.

M&S is used everywhere in the Air Force because better decisions and better training make better warfighters.

—1995 U.S. Air Force Modeling and Simulation Master Plan

In addition, until the Federal Acquisition Regulation changes, many of the steps and streamlining options are, in fact, not allowed. Unless program managers receive sufficient latitude to employ these alternative techniques without the expectation that they must solely endure the pain and shoulder the risks, on those occasions when the fledgling technology fails, they will not take the risk. Only when the Departments sponsor key programs to do some classic side-by-side comparisons of applications using simulation versus traditional approaches, can the new technologies prove they will work, saving time and money. Then it will be possible to see Simulation Based Acquisition achieve its essential role.

Let me briefly take you back in history a few years. At the risk of sounding trite, our civilization is just beginning to shift from the Industrial Age to the Information Age; we are going through all the dynamic and sometimes painful processes of change. If we look at how long it took our culture to go through the Industrial Revolution, we can imagine what's in store for us. Shifting from a focus on products and assembly-line thinking to information services and distributed collaboration, will clearly be a large leap. Planners, modelers, program managers, product managers — for many in our acquisition workforce, this shift in focus may not seem efficient or pleasant.

When we add these issues to the challenges resulting from the end of the Cold War and the huge push to expand to "operations-other-than-war" missions, our culture is going through an era that makes the '60s look positively calm. Only by systematic planning and careful application of new technologies, with an eye always toward the best outcome, can this process be streamlined and acquisition become one of the domains that makes full use of available technology.

ENDNOTES

1. The Army Model and Simulation Master Plan (Headquarters, Department of the Army, 1994).
2. *Ibid*.
3. The U.S. Air Force (USAF) Modeling and Simulation Master Plan (HQ USAF/XOM, 1996).
4. *Ibid*.
5. Marine Corps Modeling and Simulation Management Office, 1995.
6. *Ibid*.
7. Marine Corps Modeling and Simulation Management Office, 1994.
8. Slatkin, N., "Policy for Modeling and Simulation"; available at **http://sneezy.nosc.mil/30_org/3Files/TSG/ASNONMNS.html** (Memorandum, 1995).
9. Kistler, J.R., "Navy Modeling and Simulation." Presentation given at the Defense Modeling and Simulation Office (Washington, D.C., 1996).
10. Graduate Degree Program established at University of Central Florida, 1994.
11. Graduate Degree Program established at Naval Post Graduate School, 1996.